Evolutionary Concept, Genetic Algorithm and Exhibition Contract in Movie Industry

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Abstract

The paper is about application of evolutionary concept, particularly the application of natural selection process, to the study of movie industry. The importance of the application is that it allows for the heterogeneity and interdependency of market agents in analyzing the economic choice decision. This complexity always presents an obstacle to the study of market behavior, especially when one has to take into account the constant reinforcing effects among the variables, which often renders the problem elusive. The paper intends to explain the economic process, particularly the evolution of exhibition contract, taking into account this complexity through the use of evolutionary concept.

Keyword: Evolutionary selection, opportunity costs, learning and sharing rule.

1 Introduction

Economic problems usually do not follow the reductionist approach, rather, the analysis on economic choices sometimes requires us to look into the interconnectedness and heterogeneity of agents and the process which the choices are made. In this situation, the diversity at the micro level, the interrelatedness, and the adaptive behavior become crucial to the analysis.

This paper intends to illustrate this complexity in the market, with application to movie industry, specifically the exhibition contract. To see the role of the contract in the industry, we first have to look into the tension which tends to arise between distributor and exhibitor. Tension between distributor and exhibitor occurs when there are increasing number of movies vying for the limited slots available in the exhibition market.

The conflict becomes apparent when we investigate the objectives of distributor and exhibitor. Distributor wants a sufficient time to play a movie, and since *prior* release demand is not known, the situation that premature termination of the run before the movie can reveal its potential is main concern to the distributor. In this line of argument, the distributor will think that if the movie has sufficient time, the revenue stream in the subsequent runs will be higher.

This objective is in conflict with the exhibitor's, when the number of screen and other movies in the portfolio are taken into account. For exhibitor, if the movie is not generating enough revenue to cover the cost (house nut) or the other movies in the portfolio can garner larger audience, the movie should be replaced. Thus, the screen management decision usually takes the effects of potential of other movies, seasonality, and the revenue stream of the movie into account.

To mitigate the conflict, revenue sharing contract is drawn to compensate exhibitor for giving longer run time for the movie. If the collected Box Office is high during the initial run, distributor's portion in the revenue sharing contract is higher, or the revenue sharing distribution should be in favor of distributor when the movie is in the initial run. This takes into account the opportunity costs that a exhibitor incurs when deciding on the run length of the movie. Large portion accrued to exhibitor when the total Box Office is low, enables exhibitor to cover its cost, and at the same time discourage replacement. Our purpose is to relate this dynamic of economic forces to the Post Darwinian natural selection process and to search for optimal contract.

Although the reason of the market behavior, especially the evolution of exhibition contract is explained in the past literature, Chisholm (1993), De Vany and Walls (1996),Mark (1998), De Vany (2002, 2004) ,Filson et al (2004), , the process, particularly how the decision is made is not explored in detail. This maybe due to the limitation of the conventional empirical method to account for the complexity and the dynamics concerned. This paper is one of the first attempt to model the movie industry using evolutionary approach, therefore, a number of methodological issues may arise. The paper is to stir discussion on the methodological aspects, especially related to movie industry.

The paper is divided into five sections. Section two relates the evolutionary concept, particularly the process, selection, mutation and replication, to the movie industry. Section three illustrates the process of Genetic Algorithm as a tool to implement the process, and search for optimal strategy. Section four analyzes the results, and section five concludes.

2 Evolutionary concept in Movie Industry

Movie industry provides a fertile framework for evolutionary thinking in view of the diversity of innovations and the constant interactions and coordinations. The creation of new innovations, the demise of the established ones, the constant shift in importance of surviving films are ever present activities. The meaning of evolution we want to refer to is the developmental idea of the internal unfolding activities and the post-Darwinian evolution of adaptation of populations under the process of competitive selection. In this subsection, we propose to connect the economic ideas, especially the constant change in the exhibition market, with the nature of evolutionary concepts. The intention is to show how the evolutionary change; selection, variation, fitness and adaptation can be useful aid to the study of industry's change.

The central point is that the evolution provides a non-equilibrium account of why the market changes. Evolutionary concepts explain the changing patterns of co-existence among the innovations, the patterns describe the relative importance of these innovations, and how the relative importance changes over time; some are eliminated and others survive in a certain time window. As such, the wide array of innovations in movie industry, and the highly competitive environment provide a perfect framework to apply the concept in the industry.

The implications of the competition in evolutionary term is two fold. It replaces the thinking of representative behavior or uniform agents, with one which has myriad of independent and different behaviors. This is the prerequisite for the evolutionary process to take place. This diversity is caused by the differentiation strategy by the industry players. The ability to adapt to new environment by the players, for example, the various capability of players to respond instantaneously to the market demands also plays a role. As the result, it gives birth to the population of movies which are varied in terms of their characteristics, and with selective significance which makes the evolution process possible.

Secondly, in the evolutionary market institution, market competition does not converge to efficiency, in the sense of resources allocation, but rather in terms of adaptation to the new development revealed throughout the run. Therefore, what distinguishes the evolutionary market is its openness to new forms of activity and the ability to eliminate the obsolete ones when a film runs out of its marketability and shelf life.

In conventional equilibrium sense, the changes may converge to a rest point, instead, in evolutionary concept, neither the changes of the types of movie nor the box office, are attracted to a static reference point. Its arguments provide a significant explanation concerning the relative importance of the agents to the development or the evolving of the characteristics of the industry. For example; the introduction of talkies in the 1930s, the practice of vertical integration of distributors and the exhibitors, blind-booking, the contracting practices and the splitting of revenues between the two parties, explain there are two forms of change in the industry; transformational change in the nature of the individual elements in the population and variational change in the composition of the population.

Thus, it is clear that the evolutionary theory is naturally a growth theory; it is about the relative and absolute rates of expansion and contraction, and about how films use resources effectively to optimize revenues throughout the run.

2.1 Selection in Movie Industry

In this sub-section, we illustrate how the selection process takes place in the movie industry, and how we can analyze the dynamics of the industry from the evolutionary perspective. We begin with an individual movie as an entity, which is the combination of genes or modules. When movie interacts and competes in the market place, the success and failure depends on the "gene" selected.

Gene refers to a particular characteristics or events which belong to a movie, for example, the amount spent on advertising, the share of the exhibition contract,the genre of the movie, the release strategy and so on which characterizes the efforts of agents to capture audience. So in each environment or time of consideration, there are different genes, and each combination or schema gives different payoff. So, there is a pool of schemata from which the industry players can choose. Evolutionary process is a search process to locate a fit schema from the library of schemata.

We next define movie as an interactor in the market place. During the interaction and competition process, if an inefficient gene, and consequently an inefficient schema is selected, it renders the full potential of an *interactor* not fully utilized. For example, if a highly potential film is released in a non peak season, it will cause the potential of the movie not fully utilized. In this case, the release strategy is the gene, and this gene causes low payoff. Or in another case, if the release is synchronized with other high potential movie, which has high cannibalization effect, the film will die prematurely. Thus, again the release pattern and the characteristics of the movie are the genes, and their combination or schema causes the film to die faster. In an evolutionary dynamic implementation, it is interactor which interacts with other interactors. And the factors which decide living and dying of the interactor are the selection of genes and combination of these genes or schema in the ongoing evolutionary dynamic process.

In a competition model of evolution, the units of selection are the sections of schema that codes for "traits" that distinguishes one interactor from another interactors in the competition to survive. For example, from the first case above, the unit of selection is done on the gene (the release pattern).

Natural selection process will alter the gene and the schema. Through selection and replication; stronger gene and schema which can endure the competition and propel the movie will be remained and subsequently replicated. For example, if time is discrete, and there are many combinations of genes in a particular time. Each of this combination gives different payoff, and therefore, schema with higher payoff will be selected to pass its traits to other schema. The process will continue until the payoff of each schema is same.

2.2 Propagation of Genes

The survival of film depends on type of genes and schema selected by the agents. Therefore, industry players have to identify for schema which suits the environment in order to survive the competition. This involves many variables or genes and also large pool of combination of these variables or schema. This requires effort to look into the many effects of the genes from other movies on the film's performance, and make adjustment or selection from the pool of genes to be taken to suit the environment. Therefore, selection process is carried out to choose the most dominant or satisficing strategy even before the film is released.

After the schema is decided, which usually takes into account the potential revenue against “house nut”, the cannibalization effect and marketability, the film is then run with other conpetitors. Thus, genes or schema selected are used to assess its suitability against environment revealed. For example, the gene (wide release pattern) is tested with the existing word of mouth of the movie. If the gene (wide release pattern) is proven to be able to generate large followings, the effort is then adopted by the agents, in evolutionary term, the gene is then propagated in the population. Thus, the spread of a particular type of schema throughout the society or in a macro level is due to the success of the gene to generate higher payoff than other genes.

3 Genetic Algorithm and Sharing Rule

We will perform simulation exercises to illustrate the evolutionary process mentioned above. We will focus on the sharing rule in the exhibition contract as an example for our case. We use Genetic Algorithm throughout the simulation exercises.

This section intends to find the most profitable schema among the population of schema using Genetic Algorithm. The population of schema is generated to reflect the different potential revenue of each schema. Each schema contributes to the derivation of fitness, and a pair of fitness are taken randomly from the population to perform crossover and selection. The fitter's gene is then passed to the weaker, and the weaker parent is replaced by the child.

We first randomly generate a population of Box Office revenue each week for a movie. In reality, distributor and exhibitor will take into account the opportunity costs,e.g. the potential revenues of other movies in the portfolio, the cannibalization effect from competitors, the distribution of revenue and the house nut in deciding whether to continue or stop the play. The combination of all these variables are converted into binary bits to enable crossover and selection.

We assume that available strategies are varying degrees of ratio in contract. We intend to find most profitable sharing rule given the demand of the movie and the other movies in the portfolio.

3.1 Generation of population

We generate a random population of revenue for a movie and potential revenue for other movies each week. The combination of these two categories reside 60 bits in a binary string; the first 30 bits reflects the film's demand and the second 30 bits belong to the potential revenue or the cost of not showing the other movie.

There are total of 70 bits in a binary string, which contributes to a schema; a combination of demand, potential demand and a exhibition contract. The feature of the contract resides in the last 10 bits of the binary string.

We generate 50 binary strings in each population in every week of a film's run, or 50 different combinations of the movie's demand and potential demand. Similarly, the feature of the contract is varied among the population given the demand of the movie.

3.2 Fitness function

A binary string's fitness is calculated based on the nett demand collected during the run, after deducting the opportunity cost; the potential demand by other films in the portfolio. Specifically, the fitness is written as:

$$\text{fitness} = (BO_i \frac{x}{x+y}) - BO_{I-i}$$

where BO = Box Office of movie i and I is the total number of movies in the portfolio (which is the opportunity cost for the exhibitor). The distributor's contract consists of two parts; the portion accrued to exhibitor (x) and (y) to distributor.

3.3 Genetic search process

Crossover allows binary string to exchange information with each other and produce new "children" in the population. In our population, selection is performed on two strings; fitter string will pass its information to a weaker string in order to improve the new generation. However, in order to search for better or to vary the choices of the individuals, we allow the new child produced to replace the one of the parents. The overall improvement is made possible by this exchange of information from the stronger individual to weaker individual.

The process; crossover and mutation, are performed on the last 10 bits of a string; which contains the information about the exhibition contract. Mutation is performed 0.002 of the time, and crossover is performed when traits from fitter individual replaced the traits in the weaker individual. The number of bits is taken randomly from the string of the parent, and pass on to the child. The child will then replace the weaker parent. Fitness is then calculated after the crossover and mutation for each string in the population. The process of the search is performed in Mathematica.

During the search process, the portion x and y in the contract are changed to suit the bearable risk level and the objectives of distributor and exhibitor. If the initial Box Office is high, then the portion x (i.e. exhibitor's share) should be low, and portion y (i.e. distributor's share) should be high. This is because the costs borne by distributor (i.e. the distribution rental and advertisement costs) are higher than what is incurred by exhibitor. And the fitness function should be in positive region in order to avoid termination by exhibitor.

After several weeks of the run and when the movie starts to decay, the portion x should be increased. At this stage, the exhibitor bears a higher risk level than in the initial stage of the film's run; the opportunity cost of showing the film increases. Thus, in order to prolong run time, the portion x is increased, and the portion y is reduced.

We will first illustrate the selection process by using the fitness function. The process searches for the highest payoff among the population. The fitter individual will pass its traits to the weaker individuals, and is allowed to improve on its fitness. The increment takes generations of search process to improve the overall fitness.

To illustrate the industry's practice, the change of the contract is limited to 90/10 (Best Week Clause), 30% for first week and second week, 40% for third week, 50% for fifth week and 60% thereafter. If the Box Office exceeded 10 million, GA will stop its search process at 10% (portion x), and will calculate the fitness. If it is lesser than 10 million, the "x" portion is limited to 30%, and calculate the fitness value.

4 Results and discussion

4.1 Contract to encourage play

In this section, we will first illustrate the improvement of the fitness function, and after that, we will show the changing contract to two types of movie.

Figure 1 through figure 8 exhibit the change of fitness through crossover and replacement of gene among the populations for generation 10 to generation 200. The method reveals which contract, given the opportunity costs and the gross revenue collected, ensure positive fitness or real revenue to the exhibitor and therefore, how large the portion of the revenue should be collected by distributor. In the first week of the run, as shown in figure 1, gene of individual contract in the population is selected and replaced by the new individual produced from the crossover and mutation. Since one of the parents quality gene is passed over to the child, better new generation is produced progressively throughout the generations. In the figures, some individuals in the population are able to progress to higher fitness, and those not able are facing high opportunity costs, which renders the fitness to be stagnant. As in figure 3, the fitness in the population is not improved as in other figures, because the opportunity cost for each situation is high, and therefore, fitness cannot be improved after 200 generations.

The exhibition contract allows distributor to optimize the revenue and at the same time avoid premature termination. This is achieved through searching for positive fitness given the opportunity costs for each film. Figure 9 exhibits the changing contract and fitness each week of the run. The film attracts high revenue from week 1 to week 7, within which the opportunity cost or the cost of not showing the other film is lower than the revenue collected for the film. This allows distributor to fix a contract between 10% to 20% and ensure positive fitness or nett revenue collected for the exhibitor. Positive fitness allows the film to run for longer period and the ratio avoids exhibitor from enjoying too high the potential of the film. However, the declining revenue after week 7th increases the contract to 90%, which belong to the exhibitor. The change allows exhibitor to extract higher revenue from the gross, and induce him to continue the play.

Figure 10 illustrates a changing contract when the film exhibits a strong leg. Opportunity cost is high in the first week of the run. To avoid termination, distributor will have to allow exhibitor to enjoy 30% of the collected revenue. This continues to the third week of the run. In week four, the BO exceeds 10 million, which triggers the Best Week Clause. To avoid too much potential paid to exhibitor, the contract is changed to 90/10 after house nut. After which, the normal rule applies until week seventh. In this week, the fitness dives to negative region, and the film is replaced.

4.2 Contract to share risks

The variability of demand is the main concern of the risk sharing contract. In the paper by Hanssen (2002) and Filson et al (2004) argue that the unpredictability of demand *ex ante* rules out the theory of asymmetric information. Furthermore, the arrival of talkies or sound in 1930s renders the change of production structure in the studio; before sound, movies are identifiable through roster of stars employed on the studio's payroll and the demand is predictable. Its introduction increases the production costs and concerns of studio's downside risk.

This high unpredictability also worries the exhibitor if he rented the film for a flat fees. If the film is rented out a flat fee to the exhibitor, the downside risk is transferred from studio to exhibitor. In the event of high budget flop, it will wipe out the entire stream of revenue which the exhibitor collected. Thus, risk sharing contract requires distributor and studio to share portion of the risk with the exhibitor.

Before sound, input from exhibitors contributed to the success of a film, through the life music accompanied during the play. In the era, exhibitors became the large residual claimant of the revenue collected, and film was rented out with a flat fee. Flat rental fee prevented shirking from exhibitor. However, with the advent of sound, risk sharing contract became the norm. The attraction of a film is no longer depends on the life sound staged by the exhibitors; people go to see movie because of the film itself. This reduces the benefit for shirking. In the sound era, allowing exhibitor to share the revenue encourages him to continue the play, and compare with flat fee, it discourages pre mature termination. Thus, sharing contract eliminates benefits for the exhibitor to shirk, and compensates him through taking the risk of prolonging the life of a film.

The risk sharing element of an exhibition contract is illustrated in our simulation exercise in figure 9. When the movie is first released, the high demand it garnered in the first three weeks of the run compensates the high risk averse party, in this case is distributor. During this interval, "Best Week Clause" and "Holdover Clause" are triggered to compensate the high risk party. Lower risk averse party, the exhibitor, is compensated with lower portion of the total revenue collected, which are in the 20% region. Based on the fitness or net revenue accrued to the exhibitor, it should be able to cover the opportunity cost or the reservation utility which are derived from the cost of not showing other movies in the portfolio.

However, the opportunity cost of the exhibitor rises in the subsequent runs of the film. This requires higher compensation to justify for the longer run life. After 7th week of the run, the opportunity cost of not showing other movies increases, i.e. the risk borne by exhibitor increases, and therefore, it deserves a higher reward to showing the film. Similarly, to encourage run length, exhibitor should be rewarded with accordance with the risk they bear. In figure 10, high opportunity cost in the first week of the run requires distributor to allow exhibitor to enjoy larger portion of the revenue. The risk drops after the film is revealed to be able to garner large followings, and therefore, the payment accrued to the exhibitor diminishes. The risk gradually increases after the 6th week of the run, and based on the risk sharing rule, it would given larger share of the revenue collected.

Thus, the revision of the dynamic exhibition contract is based on the apportionment of the risk between the parties. With assumption that the opportunity cost is not constant, due to the new introduction of new products, our simulation result shows the concave sharing rule.

5 Conclusion

The paper suggests an evolutionary approach to the study of movie industry. This application to model the complexity leads us to relook into the the economic behavior which are usually analyzed follow the reductionist approach. We argue in the paper that the complexities; interdependency of heterogenous market agents, constant interactions and learning, present a constantly reinforcing effect, which renders the decision making dynamic and non-converging. This environment, requires one to employ a different methodology to analyze the decision making process. The paper is the first to relate dynamics in movie industry to the nature, and it would create much methodological concerns. Its purpose is to stir discussion on the evolutionary concept, particularly its application to the study of movie industry.

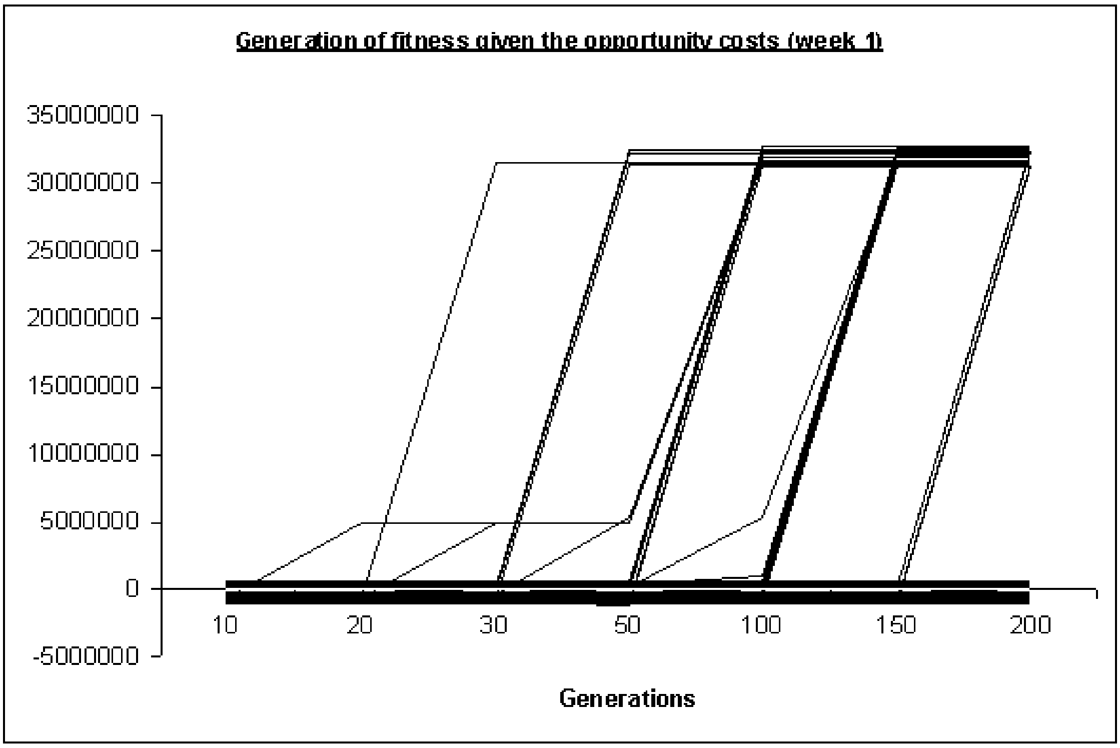

Figure 1: The change of fitness in generations given the potential revenues for other movies (week 1)

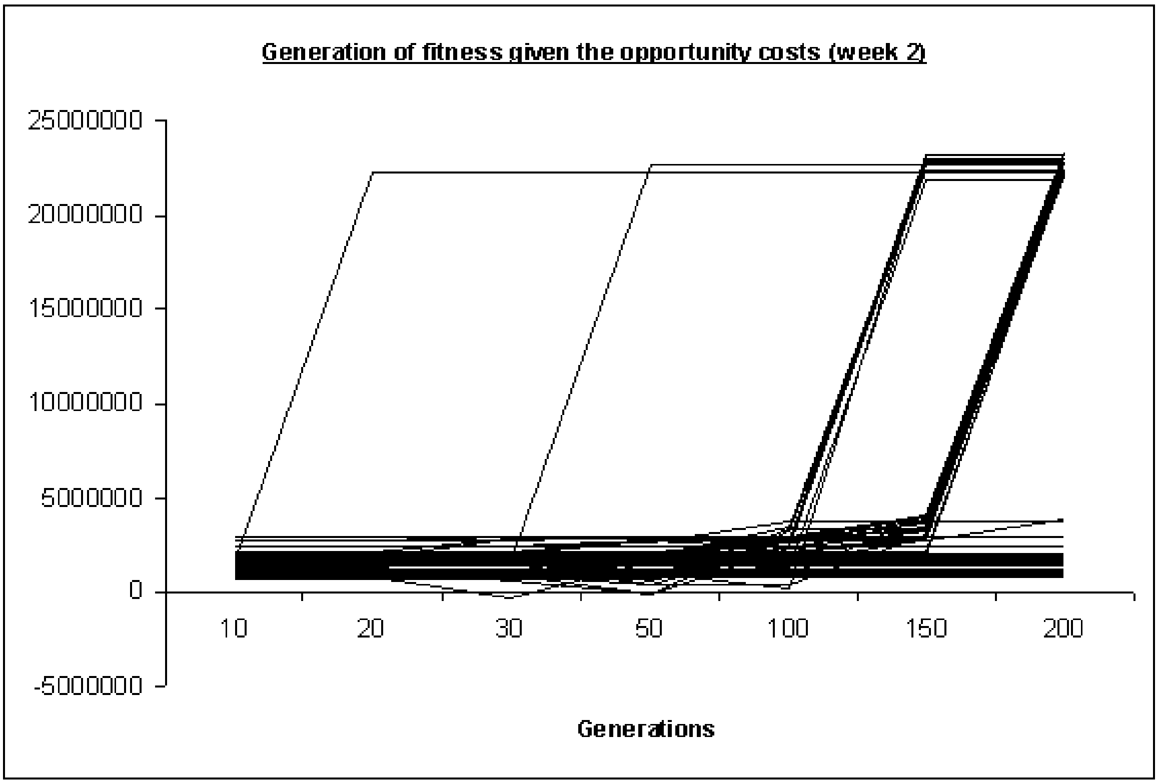

Figure 2: The change of fitness in generations given the potential revenues for other movies (week 2)

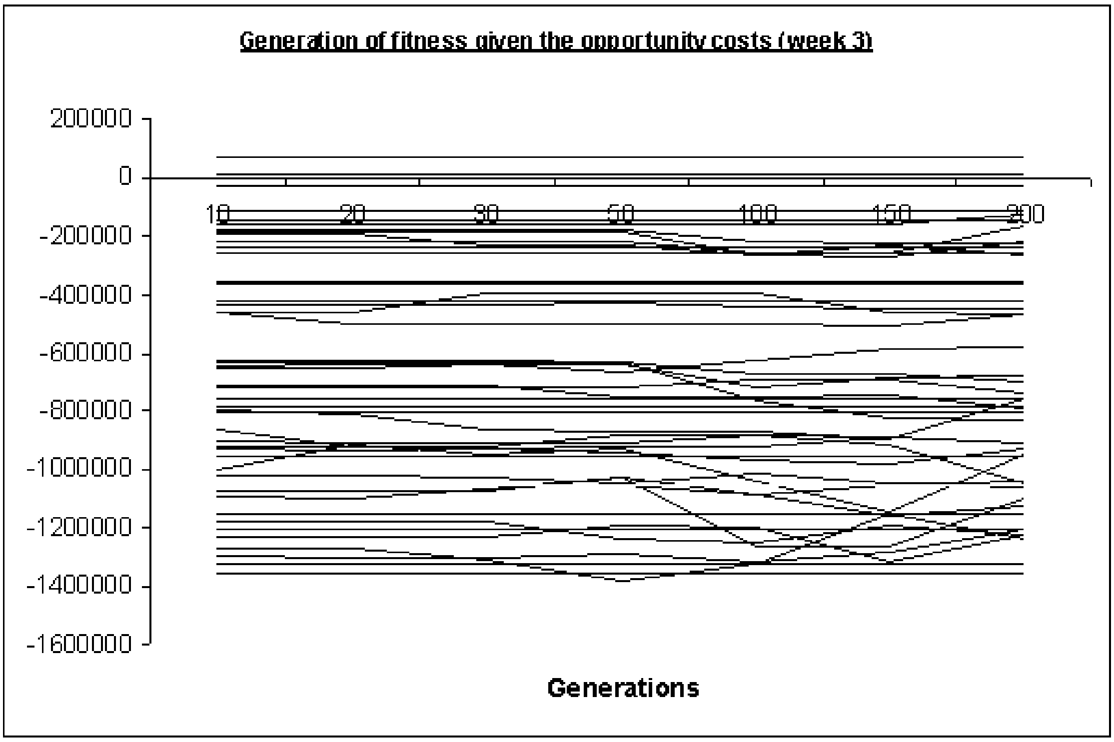

Figure 3: The change of fitness in generations given the potential revenues for other movies (week 3)

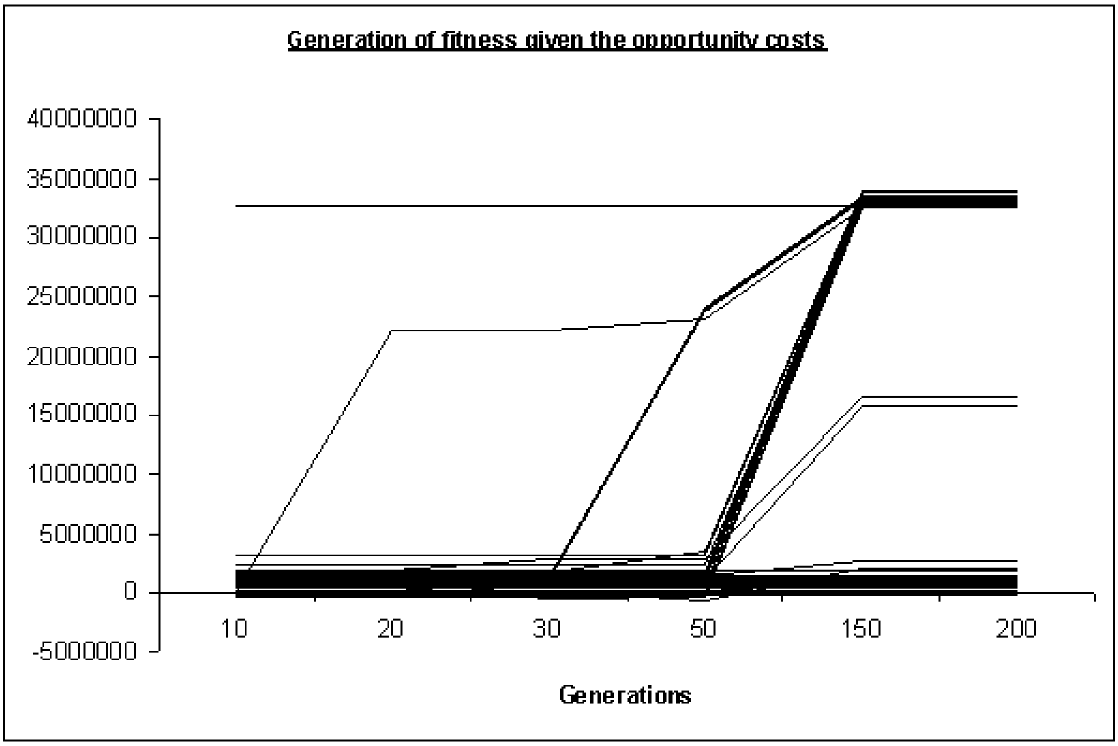

Figure 4: The change of fitness in generations given the potential revenues for other movies (week 4)

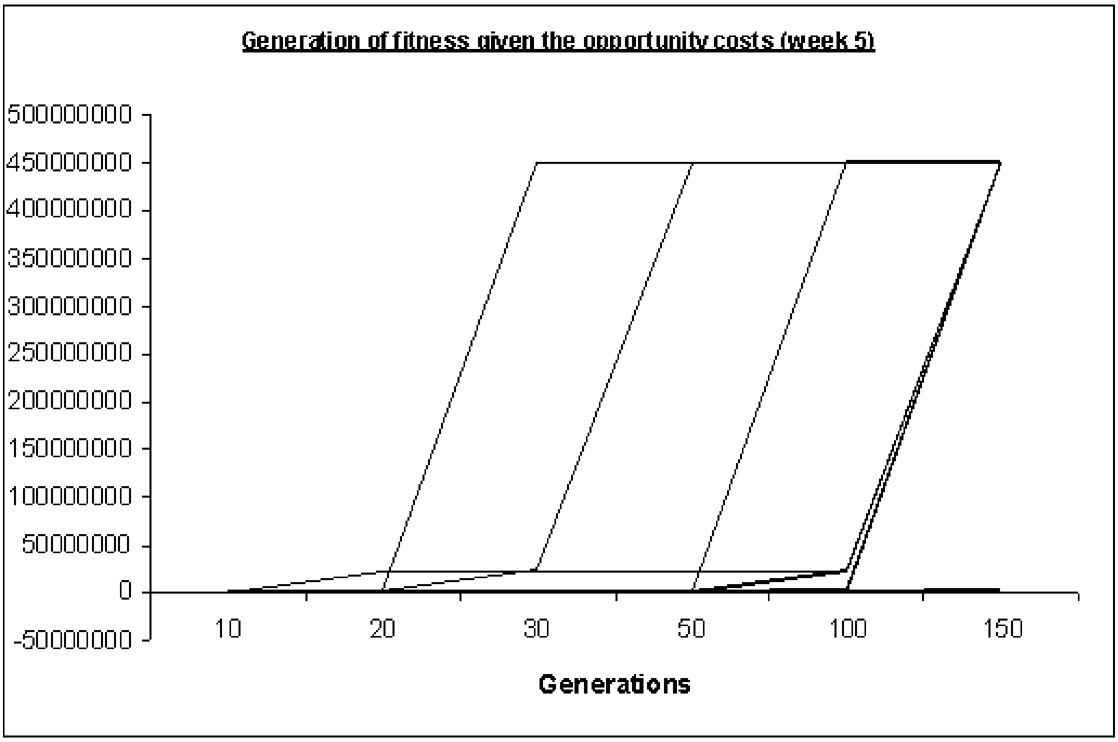

Figure 5: The change of fitness in generations given the potential revenues for other movies (week 5)

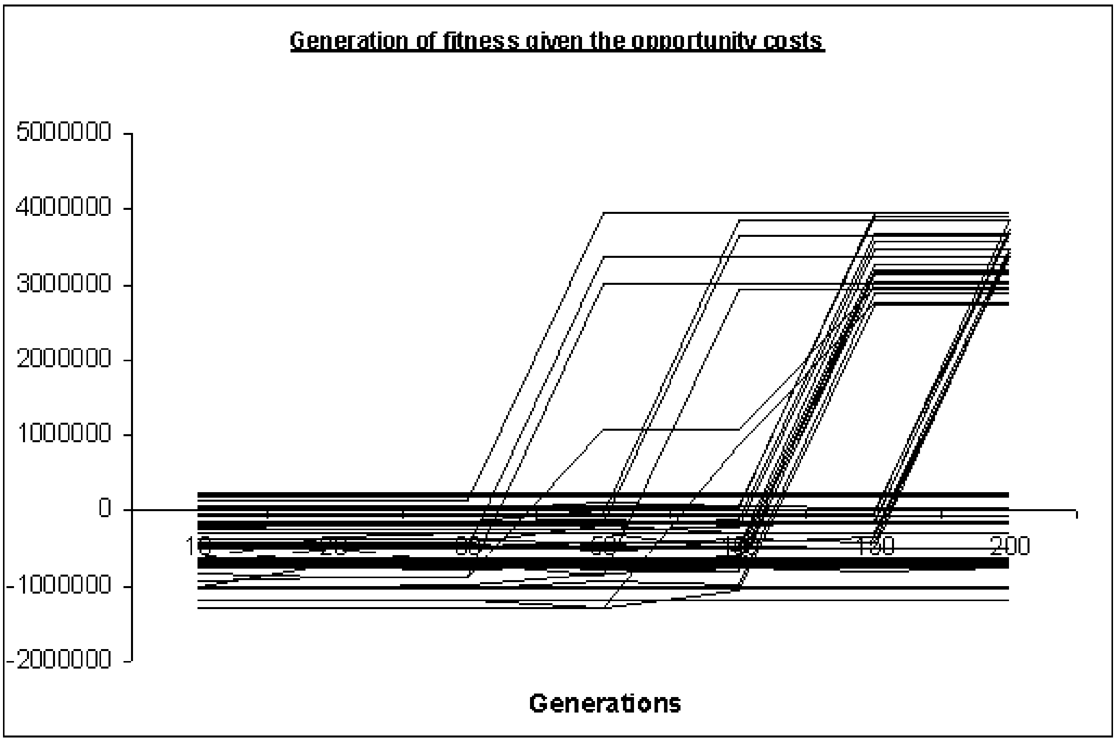

Figure 6: The change of fitness in generations given the potential revenues for other movies (week 6)

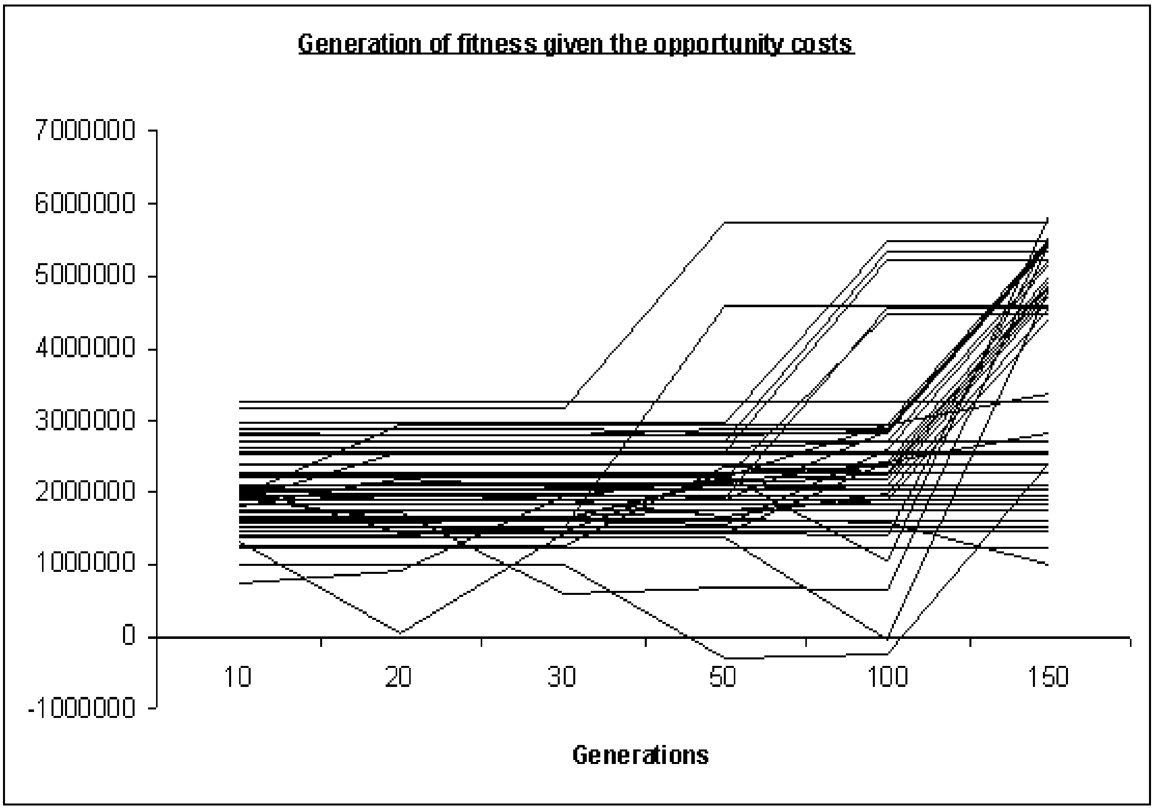

Figure 7: The change of fitness in generations given the potential revenues for other movies (week 7)

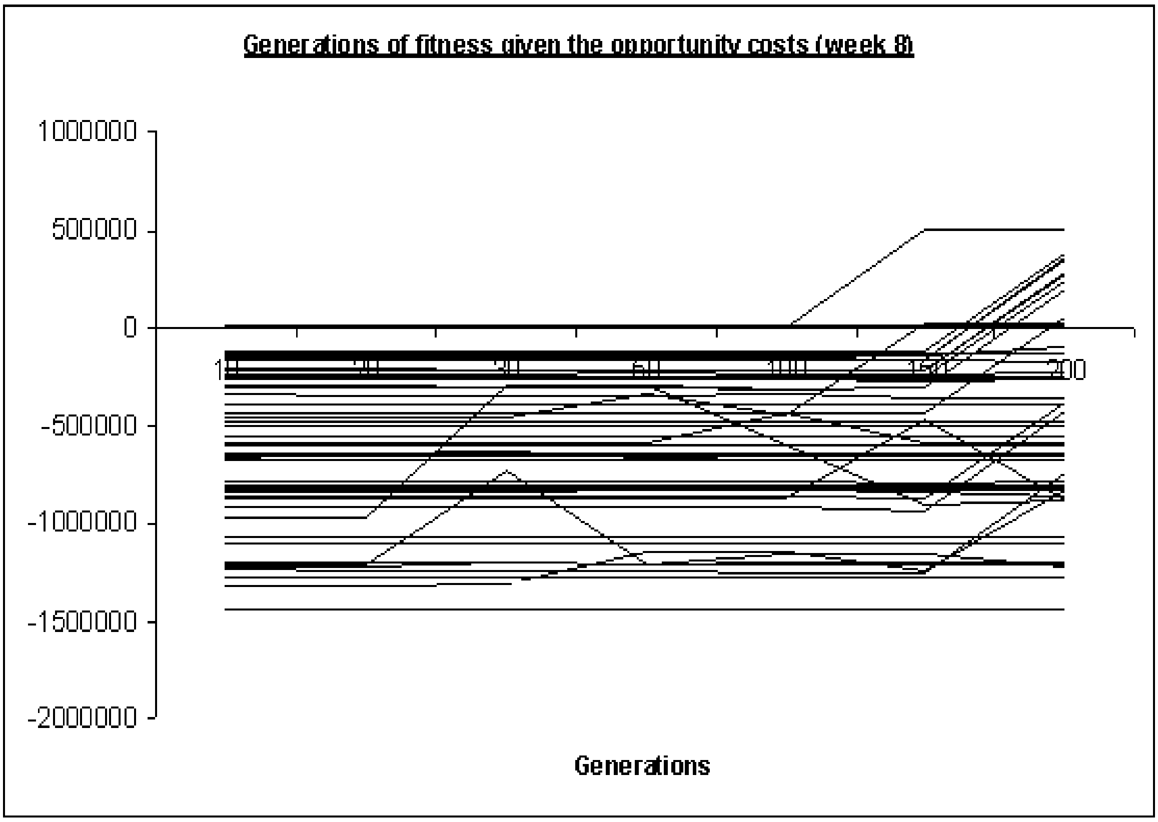

Figure 8: The change of fitness in generations given the potential revenues for other movies (week 8)

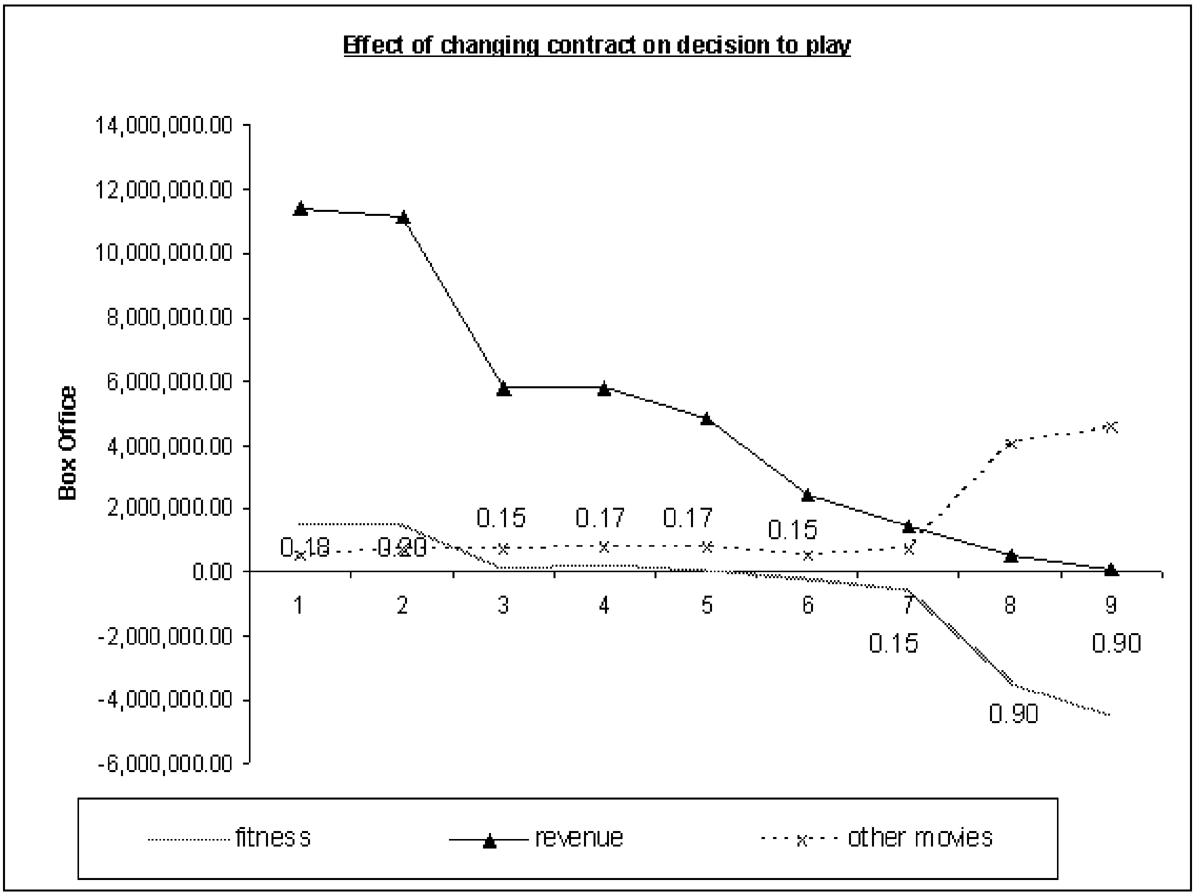

Figure 9: The effect of changing contract on extending the length of a film. The fitness function is written as $(BO_i\frac{x}{x+y}) - BO_{I-i}$, where $x = 0.1$ if $BO_i > 10m$, and if $BO_i < 10m$, $x = 0.3$ in first and second week, $x = 0.4$ in third week, $x = 0.5$ in fourth week, and $x = 0.6$ in fifth week. During the search process by GA, the constraints of the percentage is set, and the less than optimal contract is replaced. For example, during the first two weeks of the run, GA will stop at $x = 10\%$, and those with $x < 10\%$ or $x > 10\%$ will be replaced. The purpose of the process is to search for the most optimal contract, and at the same time ensures positive fitness of this selected contract. Note that if the fitness falls to negative region, means that with the given contract, the revenue cannot cover the opportunity cost. It means the movie will be replaced.

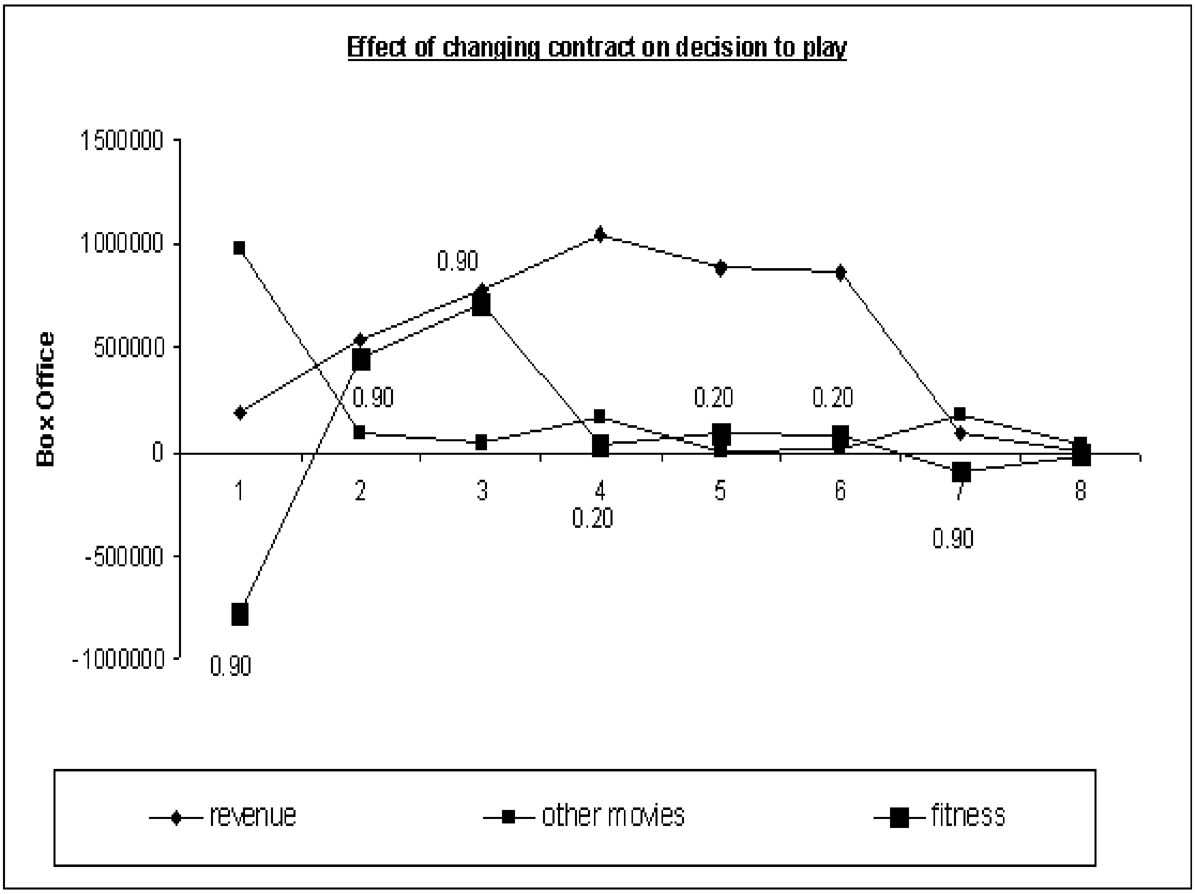

Figure 10: The effect of changing contract on extending the length of a film (when the movie exhibits strong strength

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